Experiences and Applications of Hand Held GPS at Port Stephens Council

Don Begg
Land Information Manager
Port Stephens Council

ABSTRACT

This paper details the experiences of Port Stephens Council during the investigation, acquisition and use of it's hand-held GPS units. The author is by no means an expert on the theory of GPS technology and gratefully acknowledges the help gained by attending introductory courses on the subject by AISIST / GPSCO from Bathurst.

The use of this type of equipment was seen as a way of becoming familiar with the applications and pitfalls of GPS without a high capital outlay or putting too much at stake on the absolute accuracy of the results.

THE AUTHOR

Don Begg commenced his surveying career as a Cadet Surveyor at Newcastle City Council in 1972. He completed half of the Bachelor of Surveying degree at Newcastle University and finished his academic qualifications at the University of NSW in 1977.

He undertook the City experience requirements for Registration at Newcastle and worked for 6 months in 1979 with the then Manning Shire Council at Taree to fulfil the Country experience requirements for Registration.

Following successful completion of the Board of Surveyors Examinations in March of 1981, he commenced as a Registered Surveyor with Port Stephens Council to undertake Subdivision work associated with that Council's Salamander Residential Development Project. His current position as Land Information Manager incorporates the Survey section and the Geographical Information System section within the Engineering Services Department of Port Stephens Council. Many of Council's functions involve the Mapping of different features or facilities which is how Don became involved in the investigations into the use of GPS at Council.

BACKGROUND

In the mid 1990's much was being reported about the new technology which enabled a person to locate his or her position "very accurately" using a little black box and some satellites orbiting the earth.

At the same time, Local Government was facing the prospect of having to develop data bases and management systems for everything under its control i.e. assets and facilities including roads, buildings, drains, water and sewer mains and street furniture.

The value of this "black box" technology to be able to quickly and accurately locate features on the ground was soon recognised and applications began to be developed to incorporate GPS as the position fixing tool in many data acquisition and asset maintenance systems.

At the time that Port Stephens Council (PSC) began to seriously consider purchase of any GPS equipment, survey accurate capable units were out of the range of the budget which could be justified. I was, however, keen to get started with using GPS as I believed that using the system was the best way to get a true idea of its applications and limitations.

My first contact with the hand held units came from my involvement with the Bush Fire Control which operates in association with Council. Our Fire Control staff were not afraid to meet new technology head on. In conjunction with their State body, the Bush Fire Control began testing small hand-held GPS units for tracking fire-fighting units, mapping of fire trails and plotting extents of bush fire burnout. Early developments of GPS receivers connected to lap-top computers quickly showed how relatively "inaccurate" GPS units could still provide very useful tools for a number of applications.

The request from within Council which prompted the purchase of our first hand-held GPS unit came from the Environmental Services Department. As the Port Stephens Local Government Area (LGA) has a very large proportion of non-urban land within its boundaries, there are many places where boundary monuments, e.g fences, are either not present or not necessarily indicative of property boundary locations. Hence it was not easy to relate the position of an environmentally significant feature, such as a weed infestation, to a particular property. This is especially the case in rivers which form a significant proportion of our LGA boundary.

REQUIREMENTS

The initial application for Council was in the area of mapping the location of various types of noxious weeds. As there could be the need to locate very small infestations, even down to a single plant, the unit would need to be able to achieve sufficient accuracy to enable navigation back to a position where that plant could be identified.

It was also considered desirable to be able to record some form of description against an observed position.

Given that the unit would be being used in areas of light scrub or tree cover, the ability to operate in areas of light tree canopy cover was included in the specifications. In addition, the unit would often be locating features not accessible by vehicle so portability of the unit was considered quite important.

Based on preliminary inquiries with several suppliers and advice from independent sources, accuracy requirements of 1 to 5 metres was considered to be a realistic figure both from Council's needs and from what was achievable from the type of portable unit that we had in mind.

A copy of the specification is included as Appendix 1.

SELECTION

Quotations were received from three companies and all three were asked to provide a field demonstration of the equipment offered. During the selection process I learned to read carefully the way that the accuracy was quoted on the glossy brochures! Often a sub-metre accuracy was quoted with an asterisk. At the bottom of the page was the fine print which explained the conditions under which such accuracy was obtainable, such as without selective availability and differentially corrected.

At the time of our initial investigations, differential GPS involved either post processing using a second unit as a base station or real time differential using a second unit and a radio transmitter to send corrections to the roving receiver. As with most radio transmitters, the demonstrated equipment was temperamental and had a limited range. Any differential method requiring 2 units doubled the initial purchase and set-up costs.

As some Council applications were going to involve navigation back to previously located features, real-time differential results were desirable. At the same time, a tight budget made the purchase of two units unattractive.

Fortunately, as Council was evaluating the units, the AUSNAV differential system was being developed. This promised to provide a broadcast of differential corrections 24 hours a day at relatively low cost and in a very portable form. In addition, a company in Sydney was offering a bulletin-board service of differential correction files at a fairly low cost.

The decision was taken to purchase a Magellan Pro-Mark X unit which would initially require the use of the differential files from the Sydney base station, but when available, Council would purchase an AUSNAV RDS1000 correction receiver.

This unit appeared to meet all the specifications. Diagram 1 shows how the system fitted together and the principle of the differential corrections. In its most portable

form, both the Pro-Mark and the RDS1000 could operate on internal AA batteries and only one small aerial integrated with the Pro-Mark was required. At the suggestion of the supplier, an external battery pack (on a belt arrangement) was also purchased so that a full day's field work could be achieved without the need to replace the internal batteries.

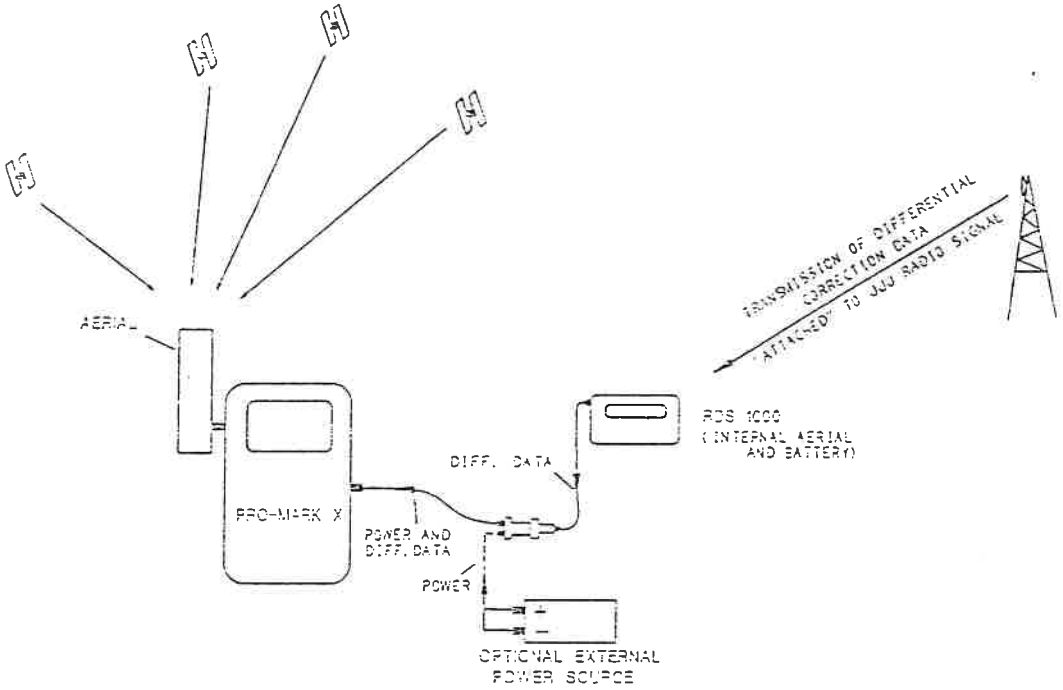

Diagram 1

GETTING STARTED

As with any new technology, all did not go exactly as planned! Initial trials with the Pro-Mark and post processing of the data were encouraging. By the time we started testing, the number of satellites was reaching the point where we had sufficient coverage providing acceptable PDOP at most times of the day.

Effective down-loading of the collected data into our Geographic Information System (GIS) has yet to be achieved. This is mainly due to Council's GIS (Genamap) which would have required considerable co-operative effort between the Magellan providers and Genasys in order to create compatible Genamap files from the output files from the GPS. For a one-off application, the costs were not justified. To date, entry of data from the GPS into the GIS has been by manual data entry methods. As the volume of data capture increases, we may have to re-assess this situation. At the time of preparation of this paper, the future of Genasys is uncertain and the continued use of Genamap by Council is under review putting any further development of down-loading on hold.

After considerable delay (due to government red-tape) with the commencement of the Newcastle AUSNAV service, we were finally able to start testing this method of real-time differential GPS. The differential correction signals are transmitted by "piggy-backing" on the JJJ radio broadcast. The JJJ station was chosen as it has the potential to cover a large proportion of the country. The correction signal is not as "strong" as the radio signal so ability to rock to JJJ on your car radio does not guarantee reception of the AUSNAV correction signal.

At the time of commencement, the AUSNAV service was provided by the AUSLIG organisation. As we were the first to use the Newcastle service, some frustrating times were experienced when our RDS1000 was not picking up a signal but the technician in Canberra assured me that the equipment was functioning. Eventually a technician was sent to Mount Sugarloaf only to discover that the JJJ signal was being encoded but not so as the RDS1000 could read it! To their credit, AUSLIG extended our initial subscription to the service to start from when a useable signal was available. In addition, we were given the chance to evaluate the system at the Premium service level. The corrections provided by the AUSNAV service are available at Basic (>10m) Intermediate (5m-10m) or Premium (1m) levels. The yearly subscription fee is now over $1400 for the Premium service.

SOME APPLICATIONS

Environmental Services

As was the original intention, the unit has been used largely by the Environmental Services section to locate noxious weeds and record their locations on Councils GIS. As with Engineering assets, more requirements are being imposed on Council to provide regular reports to other authorities in relation to Environmental matters. Council's Noxious Weeds Inspector is working with these authorities to develop automated reporting and data collection processes, and site location using this type of GPS unit is becoming an integral part of these processes.

By the very nature of the work, positions were required relative to boundaries in areas where monuments were not easily identifiable. In many cases, notices regarding the existence of noxious weeds would need to be issued to property owners, hence the need to be able to relate ground positions to property boundaries. Whilst the limitations of accuracy of the DCDB were kept in mind, the use of hand held GPS positions overlaid on our GIS cadastral layer provided a very good result in most instances. As mentioned earlier, when operating in rivers it is often very difficult to relate to monuments such as fences, especially if the river banks obscure your view of the land which abuts the river.

Another application in this area is the mapping of mosquito breeding areas. Such breeding areas are usually associated with swamp and mangrove features which are generally devoid of fences or other boundary monuments.

Engineering Services

The most obvious use for this type of positioning technology was seen as the positioning of assets such as drainage structures and street furniture.

The limitations of GPS, and low-cost hand-held units in particular, need to be kept in mind when planning to use GPS for asset positioning.

Drainage structures, such as kerb inlet pits for example, are going to be close together perhaps on either side of a 5 metre road formation. Unless numbered on the ground, they will not be easy to distinguish between in the case of trying to identify a particular structure by its co-ordinates alone if those co-ordinates are accurate to only 2 or 3 metres. When plotted, the pit may fall in the middle of the road and it may not be clear which structure it is in the case of a street intersection.

Even with the limited accuracy of this unit, it has provided a positioning method suitable for a number of applications within the Engineering Services Department. These include the plotting of long open drainage systems to determine which properties they affect and the length of drain requiring maintenance such as clearing of vegetation from banks or silt removal. This method of positioning is also quite suitable for bridges and culverts along rural roads where they are not close together and survey monuments or fences may be lacking.

From a survey point of view, we have undertaken a trial exercise with a local private surveyor to evaluate what use, if any, this instrument may be when undertaking boundary survey work. The exercise undertaken involved the identification of approximate boundary locations for a survey of Crown Land where the ground locations of boundary points were not easily identifiable from fences etc . The approximate ISG co-ordinates for the surround were obtained from the DCDB, and any adjacent survey plans showing monuments were sourced from the relevant authorities. Using the hand-held unit we were then able to navigate to any part of the land to be surveyed in order to search for above ground monuments (recent pegs, blazes in trees or fence posts) or to enable the placement of traverse points which would be suitable for later searching for reference marks or boundary marking. The ability of the Magellan instrument to display ISG co-ordinates in real-time enabled this unit to be a useful tool for this type of application.

RESULTS AND PERFORMANCE

Since the initial purchase of the Pro-Mark X for Environmental Services , a second unit has been purchased for the asset section in Engineering Services. As previously described, this unit has been used for asset location and segment location in Road Rating activities as an alternative to the rally trip meter in the vehicle.

The RDS 1000 correction receiver purchased with the Engineering unit has since been replaced with the Magellan DBR (**D**ifferential **B**eacon **R**eceiver) system. The

principle is similar to the AUSNAV system, however the correction signal is an FM transmission of lower frequency which provides for better reception over a greater distance.

The reception issue was that which lead to the change of differential unit. To be fair to the original suppliers of the RDS 1000, we were advised that the larger RDS 3000 unit was a more powerful receiver. However, given our close proximity to the transmission point (Mount Sugarloaf near Newcastle) and the better portability of the pager sized RDS 1000, we opted for the smaller unit. The RDS 3000 was tested prior to changing to the Magellan DBR, however some reception problems were still experienced and the annual subscription fee for the Premium service had risen to about $1400. The DBR signal is free to air and the initial purchase price of the unit was less than one year's Premium level subscription to the AUSNAV signal.

During investigations into the problems experienced with the AUSNAV system, the Magellan agent demonstrated the recently released DBR correction receiver to show that it did not suffer the same apparent interference to the correction signal as did the AUSNAV receiver. After testing the unit at a number of known "problem" areas, the decision was made to not renew the AUSNAV subscription and purchase the DBR. Experience with the use of the Pro-Mark X by the asset rater had shown that the unit was usually operated from the vehicle and both the Pro-Mark and DBR could be powered by a single cable from the vehicle's cigarette lighter socket. In addition, a mushroom-shaped combination aerial was purchased with a magnetic mount. This aerial gives much stronger satellite reception and acts also as the aerial for the DBR via a small splitter box. The combined unit can also be powered by a small gel-cell battery if more portability is required. Diagram 2 shows the slight change to the set-up for the unit when incorporating the DBR in place of the RDS 1000 for Differential Corrections.

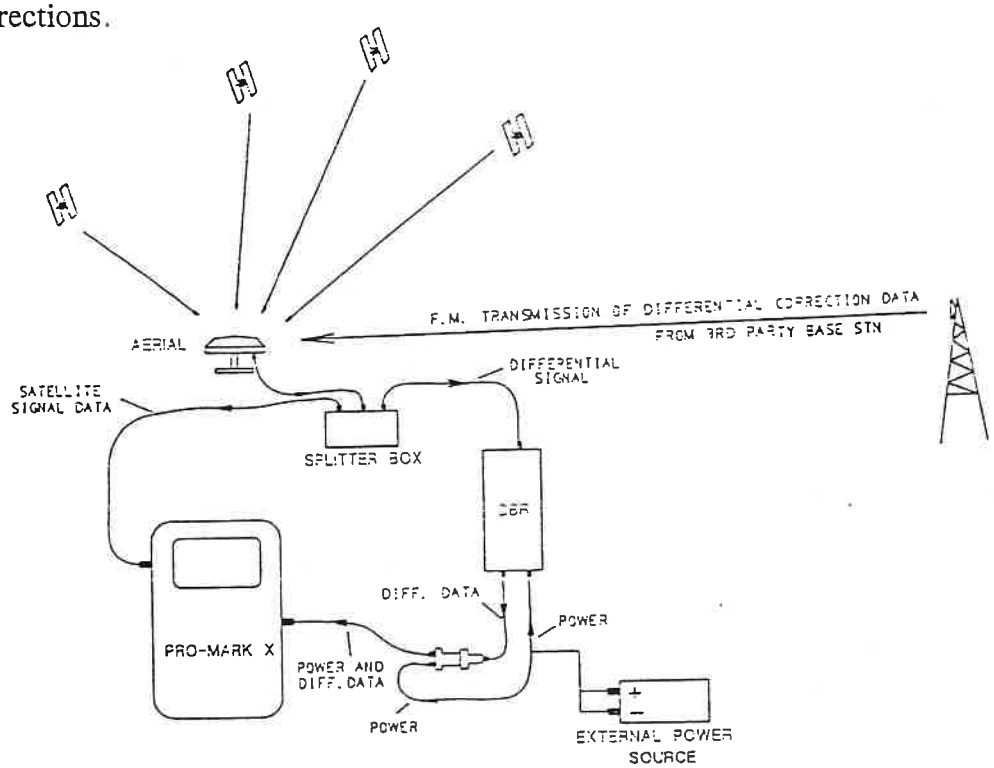

Diagram 2

ACCURACIES ACHIEVED

The following table gives a summary of the results during testing when set over a point of known co-ordinates. No attempt has been made to assess the vertical accuracy as vertical accuracy from this type of unit is known to be only half that of the horizontal accuracy and therefore is of no use for Council applications with regard to levels.

Date	Location	True E	True N	Obs E	Obs N	Diff E	Diff N	Period (min)	Interval (sec)	PDOP	S
13/11/98	R.T.	369722	1373375	369721	1373376	-1	1	15	30	1.9	not rec
				369724	1373375	2	0	15	30	2	not rec
				369723	1373375	1	0	15	30	1.9	not rec
				369720	1373373	-2	-2	15	30	2.6	not rec
				369719	1373371	-3	-4	15	30	2.8	not rec
16/11/98	B.Farm	393940.4	1371541.5	393942	1371540	1.6	1.5	15	30	2	not rec
				393941	1371539	0.6	-2.5	15	30	2.1	not rec
16/11/98	R.T.	371460.9	1374296.5	371458	1374298	-2.9	1.5	15	30	2.2	not rec
26/11/98	R.T.	369722	1373375	369721	1373376	-1	1	15	30	2.6	not rec
				369722	1373376	0	1	15	30	2.7	not rec
				369724	1373376	2	1	30	60	2.7	not rec
				369721	1373373	-1	-2	30	60	2.9	not rec
20/01/99	Karuah	390657	1385201	390658	1385201	1	0	15	30	2.6	0.8
				390659	1385200	2	-1	15	30	2	1.6
22/01/99	Karuah	390657	1385201	390654	1385197	-3	-4	single pos		2.2	N/A
				390656	1385199	-1	-2	15	30	2.1	1.9
				390658	1385204	1	3	15	30	2.1	2.2
				390656	1385203	-1	2	15	30	2.6	1.9
28/01/99	R.Terrace	369722	1373375	369721	1373375	-1	0	15	30	3.2	5.6
				369720	1373369	-2	-6	15	30	2.3	1.3
				369721	1373379	-1	4	5	10	2	0.9
				369722	1373379	0	4	15	30	2.4	1.4
				369725	1373379	3	4	15	30	2.2	1.4
				369721	1373378	-1	3	15	30	2	1.3
				369720	1373377	-2	2	15	30	2.4	1.1
				369721	1373374	-1	-1	15	30	2.5	0.9
				369723	1373375	1	0	3	1	2.6	0.7
				369724	1373378	2	3	3	1	2	1.7

These observations were not considered to be exhaustive or conclusive. Some trends may be evident in relation to the comparison between 180 single second averaged observations (i.e. 3 minutes of observations) and 30 readings taken at 30 second intervals and then averaged (i.e. 15 minutes of observations). Through my limited experience, the "s" value appears to be a good indicator towards the accuracy of a set of averaged position fixes. The "s" value is the standard deviation of horizontal position variation. It would seem that a low "s" combined with a low PDOP would mean that there is a good probability that the resulting averaged position will be within 1 - 2 metres of the true position.

SOME PROBLEMS AND LESSONS LEARNED

Overall, Council has been quite satisfied with the performance of the Pro-Mark X units. However, there are a number of components which go together to make the system work and problems with any one component can bring the system down. Unfortunately, the user has no control over most of these components and frustration can arise when you go into the field to use the GPS and satisfactory results are not possible because one component is not available.

Since using this unit, I have experienced "failure" in most segments of the system. On one occasion, the Pro-Mark X was unable to find any satellites although the aerial had a clear view of the sky and sufficient satellites should have been available, according to computer predictions. Although not confirmed as the cause, some users were notified that Military tests were being undertaken at the time to see if they could turn the satellite signals on and off from ground stations. These tests were not supposed to affect the Port Stephens area, but a function available within the Pro-Mark was able to confirm that no satellites would be available in my area until a specific time. I made a point of observing at exactly the nominated time and the signals appeared right on cue, suggesting that they had been "turned off". The satellites are continuously transmitting data about their "health" and I presume that the Pro-Mark was able to read those messages and display the time when the signal would be turned back on.

Early failures of the differential signal component certainly provided for much "hair-pulling". The initial problems with the AUSNAV signal resulted from system failure at the encoding stage. Further problems with loss of signal in certain areas of the shire resulted in the ultimate discarding of the RDS 1000 for the Engineering unit. It became apparent that the Pro-Mark X blocked the AUSNAV signal in some places, generally in areas where the AUSNAV signal was a little weaker. Since the Pro-Mark X and RDS 1000 were provided by different organisations, neither could provide an explanation, let alone a cure, although the Magellan agent confirmed that the problem was real.

Recent testing of the Magellan DBR has indicated the presence of a similar problem although it (so far) has been overcome by ensuring that the Pro-Mark is turned on before the DBR is activated. Further investigation will be made into this problem.

To complicate matters, complete loss of the DBR signal has also been experienced. Whilst the DBR hardware is marketed by Magellan, the broadcast of the signal is under the control of another organisation. Following inquiries to that organisation during the complete loss of signal, the problem was identified as due to power interruption (by the power supplier) at the transmission point. The interruption was for 10 hours and the back-up system was only good for about 4 hours. As the signal is free-to-air, it would be impractical to advise all users that there was to be a "black-out".

CONCLUSIONS

Despite the problems outlined in the previous section, I consider that the use of the hand-held GPS at PSC has been very successful. It is now an every-day tool for the Noxious weeds inspector and I am confident that we will continue to find applications for its use in asset data collection. As centimetre-accuracy units become more affordable, we will be in a good position to utilise this technology through the experience gained from the hand-held units at relatively low cost.

Appendix 1

PORT STEPHENS COUNCIL
SPECIFICATION

GLOBAL POSITIONING SYSTEM

INTRODUCTION

The Council is seeking quotations for a Global Positioning System (GPS) to be used in the identification of Noxious Plant Infestations and Mosquito Breeding areas.

The following attributes will be required in the selected system:

1. Position Accuracy 1 -5 m Horizontal

2. Portability - The unit must be capable of being easily carried by one person to places only accessible by foot and desirably adaptable to a portable external power supply.

3. The unit must be capable of operating and achieving specified accuracies in ares of light tree cover.

4. The unit must be capable of storage of line and point features with ability to describe each feature in a menu.

5. The quoted price should include all necessary software and hardware to enable the unit to effectively down-load data to the Genamap Geographic Information System.

6. The quoted price should include the cost of "Real Time" position fixing in the field.

7. The price should be accompanied by a minimum specification requirements of a PC to manage all necessary software.

8. The price should be accompanied by details of warranty and after sales service including the closest authorised service centre to Raymond Terrace.

9. The quoted price should include all options considered necessary to ensure the efficient and effective operations of the unit considering the nature and use proposed for the unit.

10. All suppliers submitting a price will be required to provide a field demonstration of the quoted unit.